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N91-19011

1990

NASA/ASEE SUMMER FACULTY FELLOWSHIP PROGRAM

MARSHALL SPACE FLIGHT CENTER

THE UNIVERSITY OF ALABAMA

DEVELOPMENT OF NICKEL HYDROGEN BATTERY EXPERT SYSTEM

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Contract No: NGT-01-002-099  
The University of Alabama



## INTRODUCTION

The Hubble Telescope Battery Testbed at MSFC employs the Nickel Cadmium (NiCad) Battery Expert system (NICBES-2) which supports the evaluation of performance of Hubble Telescope space-craft batteries and provides alarm diagnosis and action advice. NICBES-2 provides a reasoning system along with a battery domain knowledge base to achieve this battery health management function. This report summarizes an effort to modify NICBES-2 to accomodate Nickel Hydrogen battery environment now in MSFC testbed.

The prototype version of NICBES (NICBES-1) was developed by Martin Marietta Corporation. It was implemented in Intel 8086 assembly language, C and Prolog and runs on an IBM PC/AT under the DOS. The current version of NICBES (NICBES-2) is implemented on a Sun Microsystem's 386i running SunOS4.0 (UNIX) and is written in SunOS C and Quintus Prolog. The system now operates in a multitasking environment along with a mouse and window based user interface.

Figure 1 shows the structure of NICBES-2. A DEC LSI-11 based system sends the battery data to the Sun 386i via an RS-232 connection running at 9600 baud using XON/XOFF control. One telemetry burst is received every 30 seconds. NICBES-2 spawns three child processes: serialport process (SPP), data handler process (DHP) and the expert system process (ESP).

When data appears on the serial port, SPP collects it character by character and feeds it into a data pipe. The DHP reads the data pipe and converts the character data into numeric

values and reduces the raw telemetry data (by calculating averages and means of various battery parameters) in preparation for use by ESP. ESP is awakened by the user's request for a consult/advice function. Each of the three processes is awakened only when its service is desired and they go to sleep when the function is completed. The SPP has the highest priority among the processes.

In short, NICBES-2 performs orbit data gathering, data evaluation, alarm diagnosis and action advice and status and history display functions.

#### MODIFICATIONS NEEDED

The adaptation of NICBES-2 to work with Nickel Hydrogen (NiH<sub>2</sub>) battery environment requires modifications to all the three component processes. Although the general format of the telemetry input is retained, the components of the telemetry data are different. As such, the data input routines of SPP need extensive changes. Because of the differences in the data collected between the NiCad and NiH<sub>2</sub> batteries, all DHP routines require changes. The structure and the reasoning mechanism of ESP remain the same. But the rule base needs to be examined and changed to accomodate the NiH<sub>2</sub> battery domain.

#### STATUS

The modifications to the SPP are now complete. The telemetry data stream contains excessive delimiter characters that can be eliminated to reduce the data gathering overhead.

Modifications to DHP are complete. Some data items in the

telemetry ( such as Ampere-hour Out, Time-to-Trickle, Telemetry temperatures and Main and Redundant heater flags) are not utilized in ESP. Changes to DHP are needed to utilize these data. Several means and averages are now computed at 2 minute intervals (i.e. every 4 samples) rather than every other sample as in NiCad environment. Adequacy of these computation needs to be examined. The trickle charge computations need to be updated.

Modifications to ESP require consultations with NiH<sub>2</sub> battery experts to collect the rules appropriate to that domain. These rules can then be incorporated through the Simple Interactive Rule Editor (SIRE) utility available in NICBES-2 system.

The data files generated by the system seem to be unnecessarily elaborate, and create disk space shortage in the current system. File structures need to be examined to reduce their size if possible. If not, some of the files may need to be archived on the tape storage.

#### REFERENCES

- A. Bykat, "User's Manual for NICBES-2," NAG8-105, NASA/MSFC, Aug. 89.
- A. Bykat, "Program Maintenance Manuals for SPP, DHP and ESP'" NAG8-105, NASA/MSFC, August 89.
- A. Bykat, "SIRE Manual'" NAG8-105, NASA/MSFC, August 89.

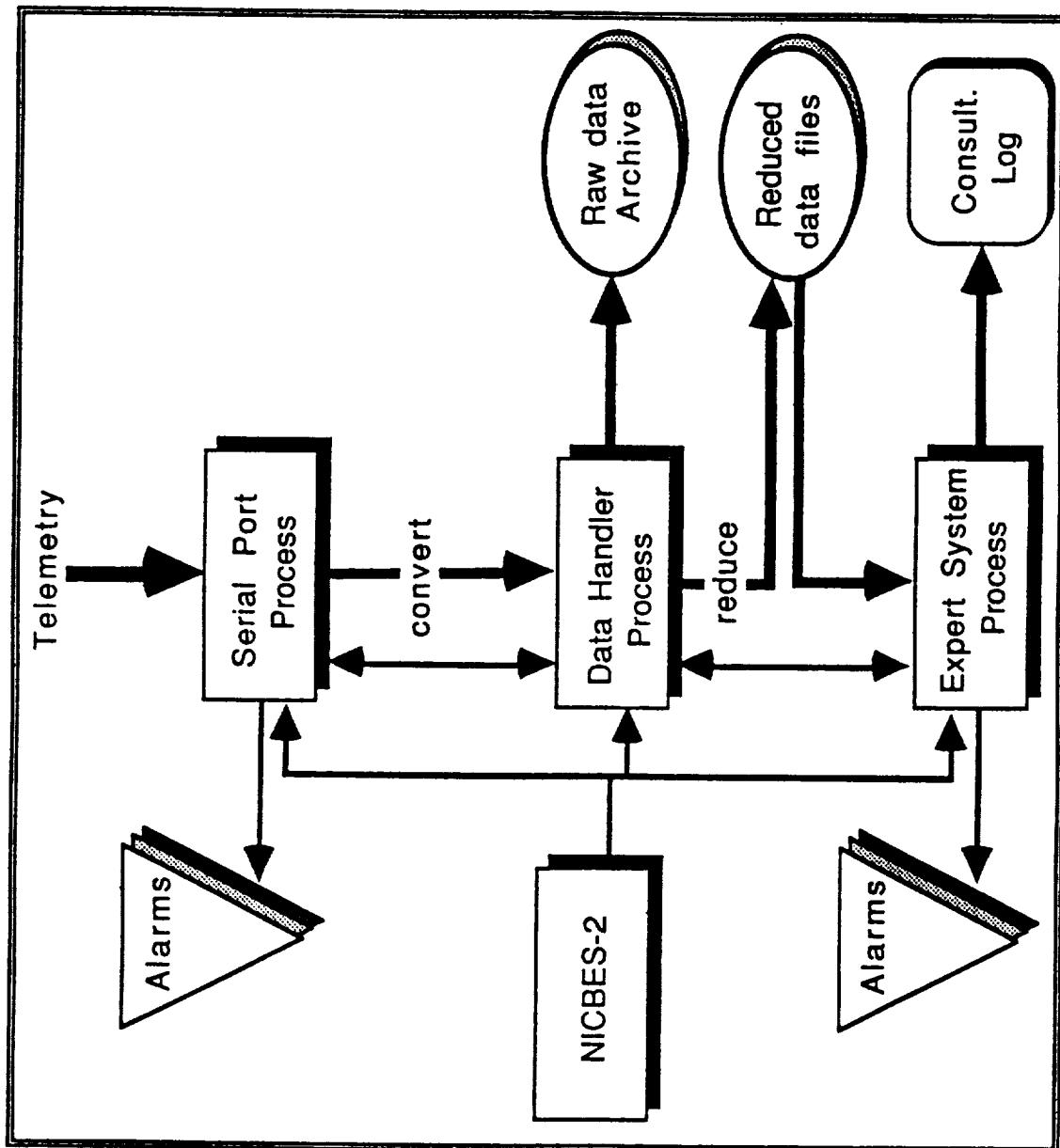


Fig.1. NICBES-2 top level structure.